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Declaration

I, Michihiko Matsuba, a translator of Fukuyama Sangyo Honyaku Center, Ltd., of 16-3, 2-chome, Nogami-cho, Fukuyama, Japan, do solemnly and sincerely declare that I understand well both the Japanese and English languages and that the attached document in English is a full and faithful translation, of the copy of Japanese Patent Application No. 2002-263831 filed on September 10, 2002.

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[TITLE OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] SPECTACLE LENS

[WHAT IS CLAIMED IS;]

[Claim 1] A spectacle lens, wherein

a refractive power invariable region in which transmitting refractive power is almost fixed is provided at almost the center of the lens,

an upper side refractive power varying region in which the transmitting refractive power continuously varies until the upper end of the lens is provided at the upper side of the refractive power invariable region, and

a lower side refractive power varying region in which transmitting refractive power continuously varies until the lower end of the lens is provided at the lower side of the refractive power invariable region.

[Claim 2] The spectacle lens according to Claim 1, wherein

the refractive power invariable region includes the widest portion in the horizontal direction of the bright field.

[Claim 3] The spectacle lens according to Claim 1, wherein

the refractive power invariable region includes the widest portion in the horizontal direction of the bright field, and

the width in the horizontal direction temporarily narrows and then widens again upward and downward from the refractive

power invariable region.

[Claim 4] The spectacle lens according to Claims 1 through 3, wherein

the refractive power invariable region is a region for viewing an object at a middle distance.

[Claim 5] The spectacle lens according to any of Claims 1 through 4, wherein

when the width in the vertical direction of the refractive power invariable region is defined as W (mm), the following relationship:

6 . W . 15

is satisfied.

[Claim 6] The spectacle lens according to any of Claim 5, wherein

when the width in the vertical direction of the refractive power invariable region is defined as W (mm), the following relationship:

8 . W . 15

is satisfied.

[Claim 7] The spectacle lens according to Claims 1 through 6, wherein

at the upper side refractive power varying region, the transmitting refractive power continuously weakens toward the upper end of the lens, and

at the lower side refractive power varying region, the transmitting refractive power continuously increases toward the lower end of the lens.

[Claim 8] The spectacle lens according to Claims 1 through 7, wherein

the aberration distribution is made asymmetric with respect to the principal meridional line.

[Claim 9] The spectacle lens according to Claims 1 through 8, wherein a non-umbilical portion on the principal meridional line is provided on the surface of the side at which the refractive power varies.

[Claim 10] The spectacle lens according to Claim 9, wherein the surface forms on the principal meridional line of the upper side refractive power varying region and the lower side refractive power varying region of said surface are changed according to powers at the center of the spectacle lens so as to have changes in the transmitting refractive power.

[Claim 11] The spectacle lens according to Claim 9 or Claim 10, wherein

the transmitting refractive power at the center of the spectacle lens is negative, and

at the upper side refractive power varying region, at least at one focusing point on the principal meridional line, surface

refractive power of a section in parallel to this principal meridional line is greater than the surface refractive power of a section orthogonal to the principal meridional line.

[Claim 12] The spectacle lens according to Claim 11, wherein

when the surface refractive power of a section in parallel to the principal meridional line in the upper side refractive power varying region is defined as first surface refractive power P1, and the surface refractive power of a section orthogonal to the principal meridional line is defined as second surface refractive power P2,

P1 (14) > P2 (14)

is satisfied, provided that P1 (14) denotes the first surface refractive power P1 at the focusing point 14mm above the vertical midpoint in the refractive power invariable region, and P2 (14) denotes the second surface refractive power P2 at the focusing point 14mm above the midpoint on the principal meridional line.

[Claim 13] The spectacle lens according to Claim 9 or 10, wherein

the transmitting refractive power at the center of the spectacle lens is positive, and

at the lower side refractive power varying region, at least at one focusing point on the principal meridional line, the surface refractive power of a section in parallel to the

principal meridional line is smaller than that of a section orthogonal to the principal meridional line.

[Claim 14] The spectacle lens according to Claim 13, wherein at the lower side refractive power varying region, when the surface refractive power of a section in parallel to the principal meridional line is defined as first surface refractive power P1, and the surface refractive power of a section orthogonal to the principal meridional line is defined as second surface refractive power P2,

P1 (-14) < P2 (-14)

is satisfied, provided that P1 (-14) denotes the first surface refractive power at the focusing point 14mm below the vertical midpoint in the refractive power invariable region on the principal meridional line, and

P2 (-14) denotes the second surface refractive power at the focusing point 14mm below the midpoint on the principal meridional line.

[Claim 15] The spectacle lens according to any of Claims 1 through 14, wherein the form of the spectacle lens inner surface is changed according to locations so as to change the refractive power.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of the art]

The present invention relates to a spectacle lens to be used for visual power adjustment, especially for correction of farsightedness.

[0002]

[Prior Arts]

Conventionally, as spectacle lenses for farsightedness to be used for correcting accommodation of sight-dimmed eyes due to aging, monofocal lenses, multifocal lenses, and progressive refractive power lenses exist. All lenses have advantages and drawbacks in comparison with other lenses. Therefore, a person wearing the abovementioned spectacle lenses for farsightedness is required to choose a spectacle to be worn in accordance with various conditions and environments. Thereby, a person wearing spectacles secures eyesight suitable for a distance to an object that he/she wants to look at.

[0003]

For example, recently, in accordance with the spread of personal computers (hereinafter, referred to as PCs), the time of use of PCs by elderly people in their work or hobbies tends to increase year after year. Therefore, recently, elderly people increasingly demand to comfortably view an object such as a PC's display or keyboard at a middle distance of about 50cm

from the spectacles (eyes).

[0004]

In order to satisfy the abovementioned demand, a monofocal spectacle lens the refractive power of which is adapted to the abovementioned middle distance is considered. The monofocal spectacle lens is very suitable for viewing an object at a middle distance. However, due to its characteristics, the monofocal lens is applied to only a shallow range in which accommodation still acts, and to view an object at a long distance, the spectacles must be changed, and this is very troublesome for the person wearing the spectacles. Particularly, in a condition where a person wearing the spectacles views an object at a short distance while viewing a display at a middle distance such as during PC operation, practicability of the spectacles significantly lowers.

[0005]

As a lens through which both a long-distance object and a short-distance object can be viewed, a multifocal lens is considered. However, in the multifocal lens, due to discontinuity of the refractive power, an obtained image jumps and provides the person with a sense of discomfort. In addition, in a case of a multifocal spectacle lens with high addition power, the difference in refractive power between the distance

portion and the near portion is designed to be great, and this is not preferable since it causes a failure in focusing on a middle-distance object.

[0006]

Considering the problems mentioned above, as described in the technical ideas disclosed in Patent Documents 1 through 4 shown below, progressive refractive power spectacle lenses the main purpose of which is to view middle- or short-distance objects have been proposed.

[0007]

[Patent Document 1]

Japanese Unexamined Patent Publication No. Sho-62-30216

[Patent Document 2]

Japanese Unexamined Patent Publication No. Hei-9-49991

[Patent Document 3]

Japanese Unexamined Patent Publication No. Hei-9-251143

[Patent Document 4]

Japanese Unexamined Patent Publication No. Hei-8-114775

[0008]

In the multi-focus spectacle lens disclosed in Patent Document 1 mentioned above, progressive addition power is provided at the lens upper and lower portions, and a middle portion in which refractive power is almost even is provided

between the distance portion and the near portion. In the spectacle lens mentioned in Patent Document 1, by providing three view distance ranges of a distance portion, a near portion, and a middle portion, it becomes possible to view distance to near objects. However, the three view distance ranges are essential, so that the vertical heights of the respective regions, especially the vertical height of the middle portion, are inevitably narrow. Furthermore, since three view distance ranges and two progressive zones are provided, the change in transmitting refractive power in each progressive zone inevitably becomes rapid. Therefore, not only lens machining becomes very difficult, but also the problems as in the abovementioned multifocal lenses occur, so that this technique is poor in practicability.

[0009]

In all cases of the progressive refractive power lenses mentioned in Patent Documents 2 through 4 above, an object at a middle distance is viewed on the progressive portion between the distance portion and the near portion. In the constructions mentioned in the respective Documents 2 through 4, great astigmatism occurs within the progressive (middle) portion, so that there is a limitation in making the bright field wide in the middle portion or distortion occurs. For example, during

PC operation, a display and a keyboard at middle distances are frequently alternately viewed. However, in the construction in which an object at a middle distance is viewed on the progressive portion, the image of the object changes when the diopter at the visual line changes even if the object distance is the same. Therefore, a person wearing the spectacles must adjust the image to a point at which he/she can most easily view the image within the progressive portion in which refractive power changes by shaking his/her head vertically or horizontally. Therefore, the person wearing the spectacles is easily tired and work efficiency lowers.

[0010]

In this specification, the bright field means a region in which an object can be viewed without image distortion or blurring, and concretely, a region in which astigmatism is 0.5D or less in terms of transmission performance. Expressions of directions such as upward, downward, horizontal, and vertical directions are based on the wearing posture of the spectacle lens.

[0011]

[Theme to be achieved by the Invention] In view of the abovementioned circumstances, an object of the invention is to provide a spectacle lens having a wide bright field suitable

mainly for viewing an object at a middle distance, more specifically, a spectacle lens which enables viewing without a sense of discomfort even when the visual line is changed from an object at a middle distance to an object at a short or long distance.

[0012]

[Means for Achieving the Theme]

In order to achieve the abovementioned object, a spectacle lens of the invention has a refractive power invariable region in which transmitting refractive power is almost fixed at almost the center of the lens, an upper side refractive power varying region in which transmitting refractive power varies until the upper end of the lens at the upper side of the refractive power invariable region, and a lower side refractive power varying region in which transmitting refractive power continuously changes until the lower end of the lens at the lower side of the refractive power invariable region.

[0013]

As mentioned above, in the invention, different from the inventions disclosed in Patent Documents 2 through 4 above, a spectacle lens that is most suitable for viewing an object for a long period of time via the lens central portion is provided by providing a refractive power invariable region at the lens

central portion. Generally, an object to be viewed through the lens central portion is at a middle distance. Therefore, in the invention, the refractive power invariable region is set to have a diopter mainly required for viewing an object at a middle distance. Thereby, a spectacle lens which is preferable mainly for viewing an object at a middle distance is provided. Namely, with the spectacle lens of the invention, for example, even when PC operation is carried out for a long period of time, a display or keyboard at a middle distance can be viewed without burden to the eyes. A person wearing the spectacles is prevented from being easily tired, and can efficiently carry out operation. In addition, a refractive power varying region in which refractive power continuously and gently changes until the lens end portion is provided at the upper and lower sides of the refractive power invariable region. Therefore, different from the abovementioned Patent Document 1, the eyes are prevented from being easily tired when they rotate upward and downward, and the visual line can be easily shifted without a sense of discomfort.

[0014]

As in the invention disclosed in Patent Document 1, in a case where three view distance ranges are provided, three diopters of the distance, near, and middle portions must be

measured. However, in the spectacle lens of the invention, lens machining becomes possible by measuring only the diopter required for viewing an object at a middle distance, manufacturing becomes extremely easy. Furthermore, in the invention disclosed in Patent Document 1, the respective three view distance ranges require fixed vertical heights. Therefore, to shorten the width in the lens vertical direction, refractive powers of the two progressive zones must be rapidly changed. Rapid changes in refractive power greatly tire the person wearing the spectacles, and are also not preferable in terms of lens designing. On the other hand, in the invention, the refractive power invariable region for the view distance ranges is only one, so that the lens width in the vertical direction can be shortened. Therefore, the spectacle lens according to the invention can be fit with a spectacle frame whose vertical height is narrow, and is preferable in terms of lens designing.

[0015]

Furthermore, according to the abovementioned construction, it becomes possible to provide a fitting point in the refractive power invariable region, so that the work of fitting into the spectacle frame becomes easy.

[0016]

It is desirable that the abovementioned refractive power

invariable region includes the widest portion of the bright field in the horizontal direction (Claim 2). Concretely, it is preferable that the width of the bright field in the horizontal direction is the widest in the refractive power invariable region, and temporarily narrows and then widens again upward and downward from said region (Claim 3).

[0017]

The refractive power invariable region is constructed so that the vertical height W thereof satisfies the following Condition (1), more preferably, satisfies the following Condition (2).

6 . W . 15...(1)

8 . W . 15...(2)

If the lower limits of the above conditions are exceeded, the vertical height of the refractive power invariable region becomes excessively low, and it becomes impossible to stably view an object at a middle distance. If the upper limits of the conditions are exceeded, the changes in refractive power at the upper side refractive power varying region and the lower side refractive power varying region become rapid, and this is not preferable.

[0018]

In daily life, a person wearing spectacles looks at an object

at a long distance through the upper region more often than the lens central portion. Furthermore, a person wearing spectacles looks at an object at a short distance through the lower region more often than the lens central portion. Therefore, the lens is preferably machined so that the transmitting refractive power of the upper side refractive power varying region continuously weakens toward the upper end of the lens, and the transmitting refractive power of the lower side refractive power varying region continuously increases toward the lower end of the lens. Thereby, for example, during PC operation, a person wearing spectacles can easily look at an object nearer than the display by rotating his/her eyes downward. During this action, the person wearing spectacles can easily look at an object more distant than the display by rotating his/her eyes upward.

[0019]

According to the invention as set forth in Claim 8, it is desirable that the aberration distribution is made asymmetric with respect to the principal meridional line. Thereby, image distortion, etc., due to aberration deviations can be prevented in a case where a person wearing the spectacles wants to rotate his/her eyes horizontally.

[0020]

By machining the surface with changes in refractive power so as to have a non-umbilical portion on the principal meridional line, it becomes possible to shallow the base curve and reduce the thickness and weight of the spectacle lens.

[0021]

According to the spectacle lens as set forth in Claim 10, the surface forms of the upper and lower portions of the refractive index invariable region on the principal meridional line of the surface at the side with changes in refractive power are changed in accordance with the diopter at the central portion of the spectacle lens, whereby transmitting refractive power scattering due to the diopter can be reduced.

[0022]

In a case where the transmitting refractive power at the central portion of the spectacle lens is negative, it is preferable that the upper side refractive power varying region is designed so that the surface refractive power of a section in parallel to the principal meridional line is stronger than the surface refractive power of the section orthogonal to the principal meridional line at least at one focusing point on the principal meridional line. In a case where the transmitting refractive power at the spectacle lens central portion is positive, it is preferable that the lower side refractive power

varying region is designed so that the surface refractive power of a section in parallel to the principal meridional line is smaller than the surface refractive power of a section orthogonal to the principal meridional line at least at one focusing point on the principal meridional line. Thereby, astigmatism in transmission performance on the principal meridional line can be satisfactorily suppressed.

[0023]

In this specification, the surface refractive power of the section in parallel to the principal meridional line at least at one focusing point on the principal meridional line means the surface refractive power in the direction of a section including the tangent vector and the plane normal vector of the principal meridional line at said focusing point. Furthermore, the surface refractive power of the section orthogonal to the principal meridional line at said focusing point means the surface refractive power of a section orthogonal to the tangent vector of the principal meridional line at this focusing point.

[0024]

More concretely, it is preferable that the spectacle lens the central portion of which has negative transmitting refractive power satisfies:

P1 (14) > P2 (14)...(3)

on the assumption that the surface refractive power of a section in parallel to the principal meridional line at the upper refractive power varying region is defined as first surface refractive power P1, and the surface refractive power of a section orthogonal to the principal meridional line at the upper refractive power varying region is defined as second surface refractive power P2.

Herein, P1 (14) denotes first surface refractive power P1 at a focusing point 14mm above the midpoint in the vertical direction on the principal meridional line in the refractive power invariable region, and

P2 (14) denotes second surface refractive power P2 at a focusing point 14mm above said midpoint on the principal meridional line. Thus, in the spectacle lens the central portion of which has negative transmitting refractive power, a point 14mm above the midpoint in the vertical direction in the refractive power invariable region is selected as a focusing point, whereby the difference between the first surface refractive power P1 and the second surface refractive power P2 appears comparatively clearly, and this achieves easier comparison between these.

[0025]

Furthermore, it is desirable that a spectacle lens the central

portion of which has positive transmitting refractive power satisfies the following condition:

P1 (-14) < P2 (-14)...(4)

provided that first surface refractive power at a focusing point 14mm below the midpoint in the vertical direction of the refractive power invariable region on the principal meridional line is defined as P1 (-14), and second surface refractive power at a focusing point 14mm below the midpoint on the principal meridional line is defined as P (-14) (Claim 14). Thus, in a spectacle lens the central portion of which has positive transmitting refractive power, by selecting a point 14mm below the midpoint in the vertical direction of the refractive power invariable region as a focusing point, the difference between the first surface refractive power P1 and the second surface refractive power P2 appears comparatively clearly, so that comparison between these can be easily made.

[0026]

Furthermore, it is desirable that the spectacle lens is changed in refractive power by changing the form of the inner surface according to locations. With this construction, lens machining can be made easier. This also has an advantage in that image blurring and distortion can be suppressed more in the case where the form of the outer surface is changed.

[0027]

[Embodiment of the Invention]

First, the main characteristics of a spectacle lens of the present embodiment are described with reference to Fig. 1 through Fig. 4. Fig. 1 and Fig. 2 are graphs showing surface performance and transmission performance, respectively, of a spectacle lens on its principal meridional line, in which the transmitting refractive power SPH at the lens central portion is a negative diopter (-4.00D). Furthermore, Fig. 3 and Fig. 4 are graphs showing surface performance and transmission performance of a spectacle lens on its principal meridional line, in which transmitting refractive power SPH of the lens central portion is a positive diopter (+2.00D). In Fig. 1 through Fig. 4, the solid line indicates changes in average refractive power, and the dotted line indicates changes in astigmatism. In the respective figures, the horizontal axis shows the average refractive power (or astigmatism) (unit: D), and the vertical axis shows the distance (unit: mm) from the midpoint of the principal meridional line in the refractive index invariable region.

[0028]

The spectacle lens of the present embodiment of the invention is characterized by having an inner surface (a lens surface

at the eye side) having the changes as shown in Fig. 1 or Fig. 3 to obtain transmitting refractive power commonly shown by the solid line of Fig. 2 and the solid line of Fig. 4. Concretely, first, a region (refractive power invariable region) Am having roughly fixed transmitting refractive power is provided at the inner surface central portion. The refractive power invariable region Am is a region for viewing an object at a middle distance, that is, a region equivalent to the progressive portion of the conventional progressive refractive power lens. A region (upper side refractive power varying region) Au in which transmitting refractive power continuously varies until the lens upper end is provided above the refractive power invariable region Am. A region (lower side refractive power varying region) Ad in which transmitting refractive power continuously varies until the lens lower end is provided below the refractive power invariable region Am.

[0029]

As shown by the dotted line of Fig. 1 and the dotted line of Fig. 3, the spectacle lens of the present embodiment is designed so as to have a portion the surface form of which on the principal meridional line is non-umbilical in order to reduce the thickness and weight of the entirety of the lens. The non-umbilical form means a condition where surface astigmatism

on the principal meridional line is not 0.

[0030]

The spectacle lens of the embodiment is machined so that the inner surface thereof has the abovementioned three regions Am, Au, and Ad. By machining the lens inner surface, an advantage in which image blurring and distortion can be suppressed in comparison with the case where the lens outer surface is machined. Concretely, in the spectacle lens of the embodiment, the inner surface is machined to change refractive power in accordance with a diopter of the central portion of the lens.

[0031]

For example, a spectacle lens the central portion of which has a negative diopter of transmitting refractive power is machined so that surface average refractive power becomes greater downward than the central portion including the refractive power invariable region. The upper side from the central portion is machined so as to have smaller surface average refractive power at a smaller gradient than the lower side. On the other hand, a spectacle lens the central portion of which has a positive diopter of transmitting refractive power is machined so that the surface average refractive power decreases upward from the central portion including the refractive power invariable region as shown by the solid line of Fig. 3. The

lens is machined so as to increase the surface average refractive power downward from the central portion at a smaller gradient than at the upper side.

[0032]

By thus changing the surface forms of the upper side refractive power varying region and the lower side refractive power varying region on the principal meridional line, changes in transmitting refractive power close to those shown by the solid lines of Fig. 2 and Fig. 4 can be obtained even when the transmitting refractive power (diopter) at the lens central portion is different.

[0033]

Furthermore, the spectacle lens the central portion of which has a negative diopter of transmitting refractive power is machined so that, at least at one focusing point on the principal meridional line at the lens upper section including the upper side refractive power varying region Au, surface refractive power (first surface refractive power) P1 of a section parallel to the principal meridional line becomes greater than surface refractive power (second surface refractive power) of a section orthogonal to this principal meridional line.

[0034]

In the present embodiment, in order to easily compare the

two surface refractive powers P1 and P2, the abovementioned focusing point is assumed as a point 14mm above the midpoint FP in the vertical direction of the refractive power invariable region Am on the principal meridional line. Then, the spectacle lens the central portion of which has a negative diopter of transmitting refractive power is machined so that, when the first surface refractive power at said focusing point is defined as P1 (14), and the second surface refractive power is defined as P2 (14), the following relationship is established between these:

$$P1\ (14) > P2\ (14) \ldots (3)$$

By satisfying Expression (3), transmitting astigmatism can be suppressed to be small in the spectacle lens the central portion of which has a negative diopter of transmitting refractive power.

[0035]

Herein, the above Expression (3) can be transformed into the following expression:

$$AS\ (14) = P1\ (14) - P2\ (14) > 0$$

Herein, AS (14) denotes surface astigmatism at the point 14mm above the midpoint FP on the principal meridional line.

[0036]

The spectacle lens the central portion of which has a negative

diopter of transmitting refractive power is machined so that AS (14) takes a value larger than 0 as shown in Fig. 1. Namely, this spectacle lens satisfies Expression (3). Therefore, as shown by the dotted line of Fig. 2, it is proved that transmitting astigmatism is satisfactorily suppressed at any location on the principal meridional line in this spectacle lens.

[0037]

Furthermore, the spectacle lens the central portion of which has a positive diopter of transmitting refractive power is machined so that the first surface refractive power P1 at least at one focusing point on the principal meridional line in the lens lower section including the lower side refractive power varying region Ad becomes smaller than the second surface refractive power P2.

[0038]

In this embodiment, in order to easily compare the two surface refractive powers P1 and P2, the abovementioned focusing point is assumed as a point 14mm below the midpoint FP on the principal meridional line. Then, the spectacle lens the central portion of which has a positive diopter of transmitting refractive power is machined so that, when the first surface refractive power at this focusing point is defined as P1 (-14), and the second surface refractive power is defined as P2 (-14), the following

relationship is established between these:

P1 (-14) < P2 (-14)...(4)

By satisfying Expression (4), transmitting astigmatism can be suppressed to be small in the spectacle lens the center of which has a positive diopter of transmitting refractive power.

[0039]

Herein, the abovementioned Expression (4) can be transformed into the following expression:

AS (-14) = P1 (-14) - P2 (-14) < 0

Herein, AS (-14) denotes surface astigmatism at the point 14mm below the midpoint FP on the principal meridional line.

[0040]

The spectacle lens the central portion of which has a positive diopter of transmitting refractive power is machined so that AS (-14) takes a value smaller than 0 as shown in Fig. 3. Namely, this spectacle lens satisfies Expression (4). Therefore, as shown by the dotted line of Fig. 4, it is proved that transmitting astigmatism is satisfactorily suppressed at any location on the principal meridional line.

[0041]

As mentioned above, the spectacle lens which is manufactured by machining a surface form according to said diopter has transmitting refractive power that is changed in accordance

with the diopter of the lens central portion as shown in Fig. 2 and Fig. 4, that is, has the abovementioned three regions Am, Au, and Ad. Next, two detailed examples of the spectacle lens having the abovementioned characteristics are described.

[0042]

[Example 1]

Fig. 5 shows a contour map of transmitting astigmatism (distribution map of equal astigmatism) of a spectacle lens 10 of Example 1. Fig. 6 shows a contour map of transmitting average refractive power (distribution map of equal average refractive power) of the spectacle lens 10. In Fig. 5 and Fig. 6, the dotted line L indicates the principal meridional line. The point FP indicates the vertical midpoint of the refractive power invariable region on the principal meridional line L, and is matched with the center of the outside diameter of the lens in this embodiment. In Fig. 5 and Fig. 6, intervals between the contour lines are all 0.5D, and the same applies to Example 2 to be described next. Fig. 7 is a graph showing transmission performance of the spectacle lens 10 along the principal meridional line L. In Fig. 7, the solid line shows transmitting average refractive power, and the dotted line shows transmitting astigmatism. In Fig. 7, the horizontal axis shows the transmitting average refractive power (or transmitting

astigmatism) (unit: D), and the vertical axis shows the distance (unit: mm) from the center of the outside diameter (the point FP). The same applies to Fig. 10 that is described below.

[0043]

The spectacle lens 10 has a central diopter SPH of 0.00D and an outside diameter of ϕ75mm. As shown in Fig. 5, the spectacle lens 10 has astigmatism distribution that is asymmetric with respect to the principal meridional line. Thereby, when the spectacles are worn, aberrations can be balanced horizontally when the eyes are rotated horizontally. Herein, the spectacle lens 10 is designed so as to have a portion whose surface form on the principal meridional line is non-umbilical. Thereby, in the spectacle lens 10, astigmatism as the transmission characteristic is effectively suppressed as shown by the dotted line of Fig. 7.

[0044]

As shown in Fig. 5 and Fig. 6, the horizontal width of the bright field in the spectacle lens 10 is designed to be the widest in the refractive power invariable region. In this embodiment, as shown by the arrow line in Fig. 5, the horizontal width passing through the point FP is designed to be the widest. In addition, the horizontal width of the bright field temporarily narrows and then widens again upward and downward from the

refractive power invariable region including the point FP.

[0045]

As shown in Fig. 7, the spectacle lens 10 has a refractive power invariable region with a vertical height of 8mm at the lens central portion. Namely, the refractive power invariable region of the spectacle lens 10 satisfies both the abovementioned conditions (1) and (2), and a sufficient width is secured for this region for viewing an object at a middle distance. Furthermore, the spectacle lens 10 has an upper side refractive varying region in which transmitting refractive power continuously decreases toward the lens upper end at the upper side from the refractive power invariable region. Moreover, the spectacle lens 10 has a lower side refractive power varying region in which transmitting refractive power continuously increases toward the lens lower end at the lower side from the refractive power invariable region.

[0046]

Thus, the spectacle lens 10 is formed so that the spectacle central portion is set as a refractive power invariable region, and the bright field of this refractive power invariable region becomes the widest. Thereby, the lens becomes preferable for a condition where the frequency of viewing an object at a middle distance, such as display observation during PC operation is

high. Furthermore, a refractive power varying region in which transmitting refractive power varies toward the lens end portions is provided at the upper and lower sides from the refractive power invariable region, and the gradients thereof are made gradual. Thereby, the burden on the eyes when they are rotated upward and downward is reduced, resulting in occurrence of eyestrain being suppressed.

[0047]

[Example 2]

Fig. 8 shows a contour map of transmitting astigmatism of a spectacle lens 20 of Example 2. Fig. 9 shows a contour map of transmitting average refractive power of the spectacle lens 20. Fig. 10 is a graph showing transmission performance along the principal meridional line L of the spectacle lens 20. As in Fig. 3, in Fig. 10, a solid line shows the transmitting average refractive power and a dotted line shows the transmitting astigmatism.

[0048]

The spectacle lens 20 has a central diopter SPH of +2.00D and an outside diameter of ϕ85mm. As shown in Fig. 10, the spectacle lens 20 has a refractive power invariable region with a vertical height of 12mm at the lens central portion. Namely, the refractive power invariable region of the spectacle lens

20 also satisfies both the abovementioned condition (1) and condition (2) as in the case of the spectacle lens 10 of Example 1, and a sufficient width is secured for this region for viewing an object at a middle distance.

[0049]

The spectacle lens 20 has astigmatism distribution that is asymmetric with respect to the principal meridional line (Fig. 8). Furthermore, the spectacle lens 20 is designed so as to have a portion the surface form of which on the principal meridional line is non-umbilical. Thereby, astigmatism of the spectacle lens 20 as a transmission characteristic is effectively suppressed as shown by the dotted line of Fig. 10. As shown by the arrow line in Fig. 8, the horizontal width of the bright field of the spectacle lens 20 is designed so as to be the widest in the refractive power invariable region. The horizontal width of the bright field temporarily narrows and then widens again upward and downward from the refractive power invariable region including the point FP.

[0050]

Furthermore, as in Example 1, the spectacle lens 20 has an upper side refractive power varying region in which transmitting refractive power continuously decreases toward the lens upper end at the upper side from the refractive power invariable region.

Moreover, the spectacle lens 20 has a lower side refractive power varying region in which transmitting refractive power continuously increases toward the lens lower end at the lower side from the refractive power invariable region.

[0051]

The spectacle lens 20 thus constructed has nearly the same effects as those of the spectacle lens 10 that has been mentioned above. Furthermore, the spectacle lens 20 is formed so that the vertical height of the refractive power invariable region becomes higher than that of the spectacle lens 10 of Example 1. Thereby, the spectacle lens 20 is designed so as to be more suitable for a condition where frequency of viewing an object at a middle distance is high and to be comfortably used by a person wearing the spectacles.

[0052]

Embodiments of the invention are described above. Furthermore, the spectacle lenses of the above embodiments are machined so as to have predetermined changes in transmitting refractive power on the inner surfaces thereof, however, it is also possible that the outer surface or both the inner and outer surfaces are machined.

[0053]

[Effects of the Invention]

As described above, the present invention provides a spectacle lens which has a refractive power invariable region having a wide bright field, suitable for viewing an object at a middle distance, at the lens central portion.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

A graph showing surface performance on the principal meridional line of the spectacle lens the central portion of which has a negative diopter of transmitting refractive power of the embodiment of the invention.

[Fig. 2]

A graph showing surface performance on the principal meridional line of the spectacle lens the central portion of which has a negative diopter of transmitting refractive power of the embodiment of the invention.

[Fig. 3]

A graph showing surface performance on the principal meridional line of the spectacle lens the central portion of which has a positive diopter of transmitting refractive power of the embodiment of the invention.

[Fig. 4]

A graph showing surface performance on the principal meridional line of the spectacle lens the central portion of

which has a positive diopter of transmitting refractive power of the embodiment of the invention.

[Fig. 5]

A contour map of transmitting astigmatism of the spectacle lens of Example 1.

[Fig. 6]

A contour map of transmitting average refractive power of the spectacle lens of Example 1.

[Fig. 7]

A graph showing transmission performance along the principal meridional line of the spectacle lens of Example 1.

[Fig. 8]

A contour map of transmitting astigmatism of the spectacle lens of Example 2.

[Fig. 9]

A contour map of transmitting average refractive power of the spectacle lens of Example 2.

[Fig. 10]

A graph showing transmission performance along the principal meridional line of the spectacle lens of Example 2.

[Description of Symbols]

10, 20 spectacle lens

L principal meridional line

[TITLE OF DOCUMENT] ABSTRACT

[ABSTRACT]

[Object] To provide a spectacle lens which has a region having a wide bright field, suitable for viewing an object at a middle distance.

[Solution Means] A spectacle lens is constructed so that a refractive power invariable region in which transmitting refractive power is roughly fixed is provided at almost the center of the lens, an upper side refractive power varying region in which transmitting refractive power continuously varies until the upper end of the lens is provided at the upper side from the refractive power invariable region, a lower side refractive power varying region in which transmitting refractive power continuously varies until the lower end of the lens is provided at the lower side from the refractive power invariable region, and said refractive power invariable region is a region for observation of an object at a middle distance.

[SELECTIVE DRAWING] Fig. 5

Fig. 1, Fig. 3

Surface performance

Fig. 2, Fig. 4, Fig. 7, Fig. 10

Transmission performance

Fig. 5, Fig. 6, Fig. 8, Fig. 9

Principal meridional line L

Fig.1

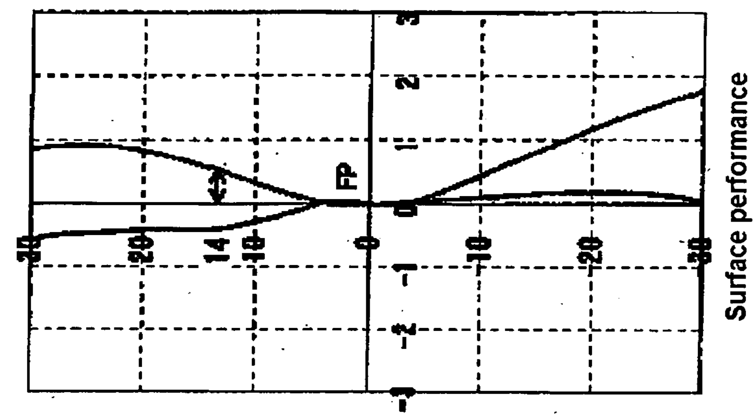

FP
14
Surface performance

Fig.2

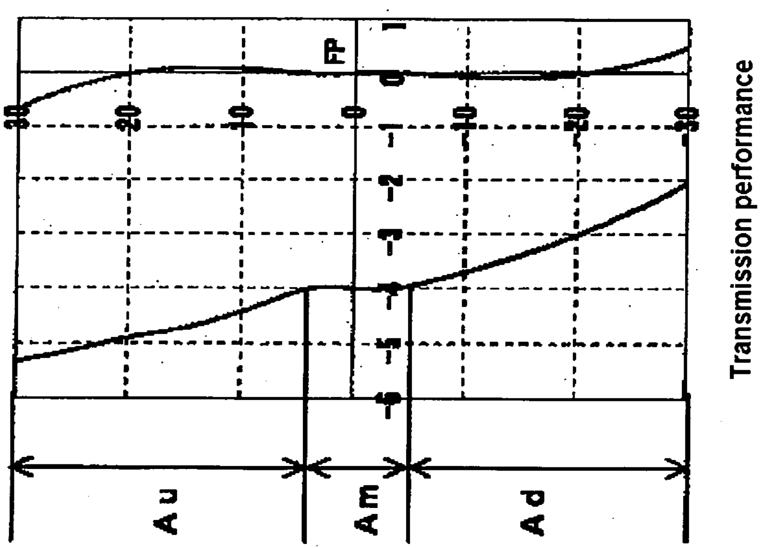
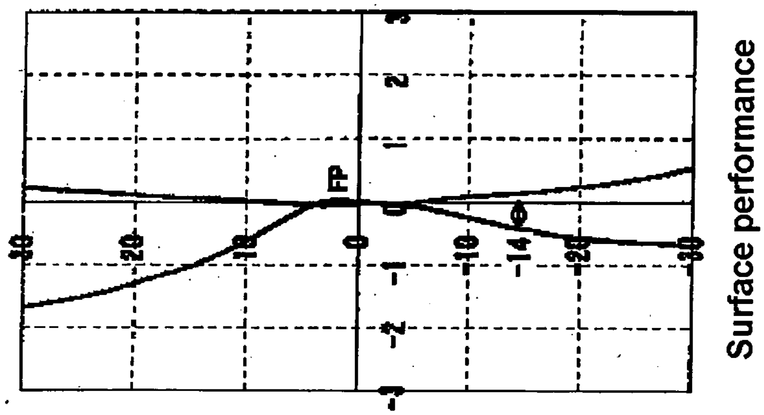
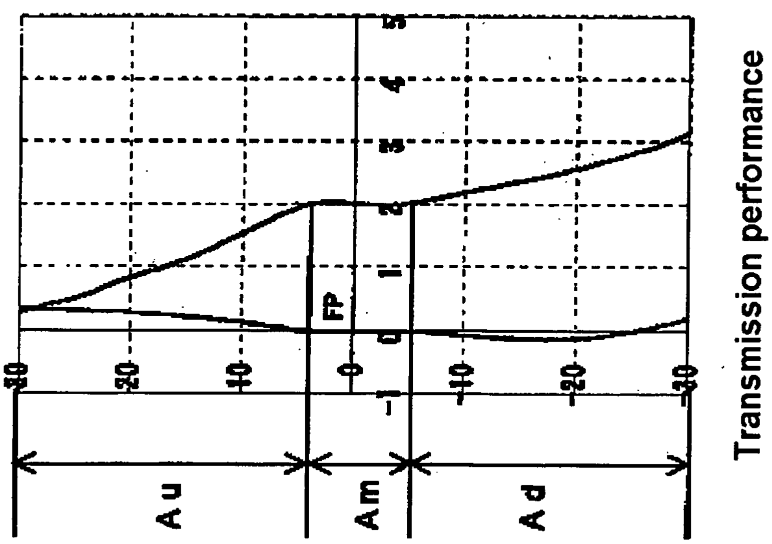

FP
Transmission performance
A u
A m
A d

Fig.3



Surface performance
FP
-14

Fig.4



Transmission performance
FP
A u
A m
A d

Fig.5

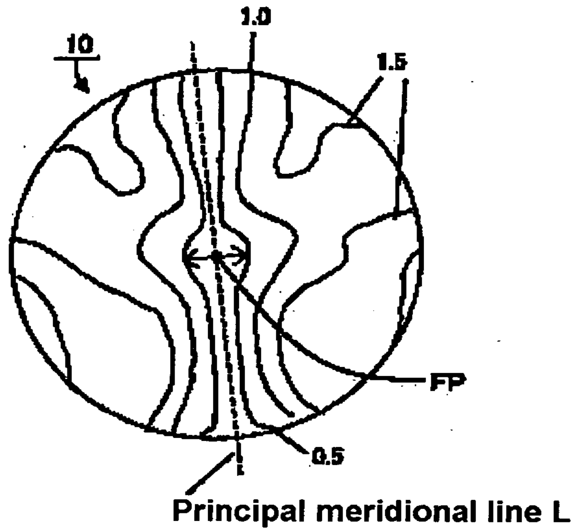

10
1.0
1.5
FP
0.5
Principal meridional line L

Fig.6

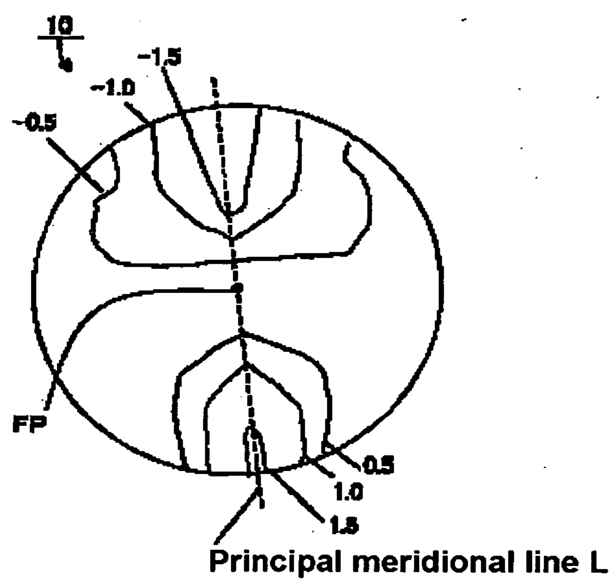
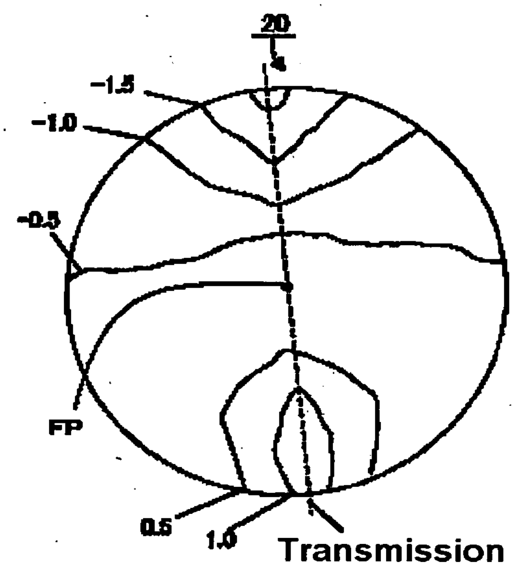
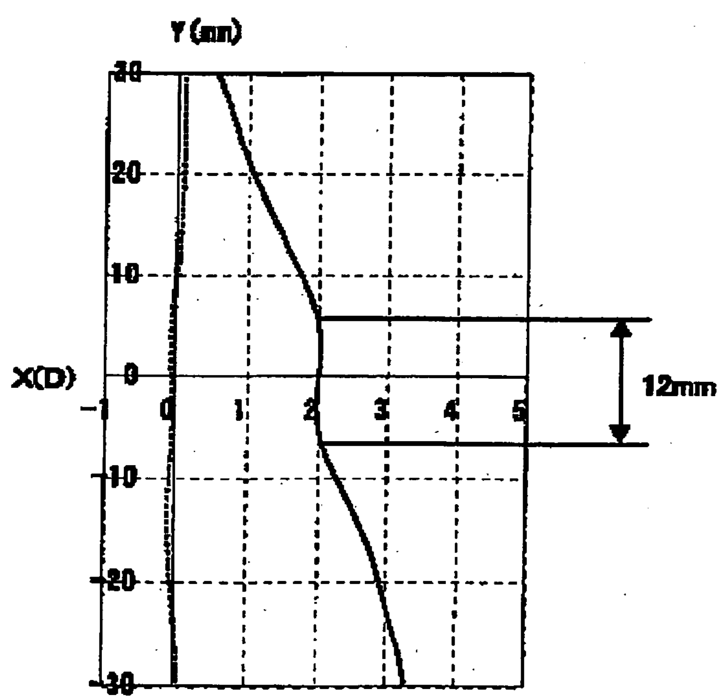

10
-1.5
-1.0
-0.5
FP
0.5
1.0
1.5
Principal meridional line L

Fig.7



Transmission performance

Fig.8



Principal meridional line L

Fig.9

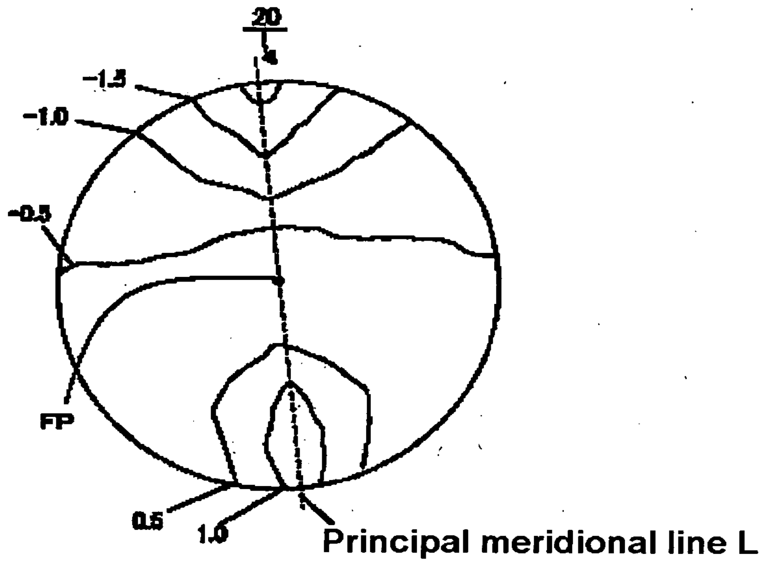
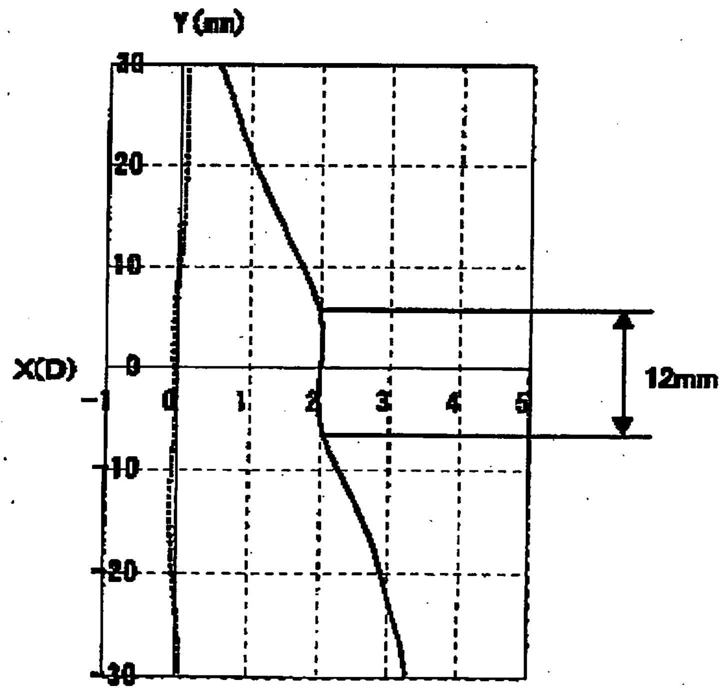


Fig.10



Transmission performance